# OVERSUMMERING OF EGGS OF *HALOTYDEUS DESTRUCTOR* TUCKER (ACARI: PENTHALEIDAE): DIAPAUSE TERMINATION AND MORTALITY

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**Abstract**

Diapause termination and mortality were examined in oversummering eggs of *H. destructor* collected from two pasture sites near Leeton, New South Wales, which differed in soil type and drainage. The effect of soil type and moisture on these factors was also investigated experimentally. Diapause termination was less reliable and mortality higher in eggs obtained from poorly drained clay than from well drained sandy loam. Soil type and moisture did not affect timing or extent of diapause termination. However, moisture increased mortality. Mortality of eggs on permanently wet sand was significantly greater than in any other treatment. The results from this study indicate that summer rainfall can have a deleterious effect on survival of oversummering eggs of *H. destructor*, particularly on heavy poorly drained soils.

## Introduction

*Halotydeus destructor* (red legged earth mite) is a major pest of winter crops and pasture in southern Australia (Wallace 1940; Wright 1961; Hely et al. 1982; James 1987). Most serious damage occurs to young plants although productivity of established pasture can be seriously reduced by large populations (Nicholas and Hardy 1976). Chemical control of earth mites can be unsatisfactory particularly when population levels are high, and there is a need to develop improved management strategies which take greater account of pest biology and ecology.

Mite activity commences following the onset of autumn rain and low temperatures and continues until late spring (Wallace 1970). Oversummering occurs as heat and desiccation resistant eggs which are retained within mite bodies following their death in spring (Norris 1950). Oversummering eggs undergo an aestival diapause which ensures dormancy until autumn (Wallace 1970a, 1970b). Diapause development is completed following exposure to high temperatures. Wallace (1970a) showed exposure of eggs to 52°C and 50% R.H. for 32 days was the most effective treatment to terminate diapause. Oversummering eggs in mite bodies on the soil surface are exposed to extremely high temperatures from October onwards. Wallace (1970a) reported maximum soil surface temperatures of 55-64°C in Western Australia. It is therefore likely that oversummering eggs regain competency for development sometime before the occurrence of autumn rain.

Wallace (1970a) stated that temperatures of 30-50°C were lethal to moist oversummering eggs of *H. destructor*. Exposure of moist eggs to 50°C for one day killed all the embryos. Consequently, summer rainfall may be an important source of mortality to oversummering egg populations (Wallace and Mahon 1971).

This study presents information on the effect of site, soil type and moisture on egg diapause termination and mortality in oversummering populations of *H. destructor*.

**Materials and Methods**

*Egg diapause termination and mortality in field populations*

Oversummering egg populations of *H. destructor* were sampled from two pasture sites at Yanco near Leeton in the Murrumbidgee Irrigation Area from November - March in 1988/89 and November - February in 1989/90. These sites were 5 km apart and differed considerably in drainage and soil type. YAI (Yanco Agricultural Institute) was an improved dryland pasture on well drained, sandy loam. LFS (Leeton Field Station) was an improved irrigated pasture on heavy clay with poor drainage. Samples were collected at two or three week intervals in 1988/89 and fortnightly in 1989/90. Waterlogged conditions prevented collection of a sample at LFS in February, 1990.

Surface soil samples were removed from each site and examined in the laboratory for the presence of dead earth mites. They were collected as shallow scrapings using a trowel to half fill a 40 x 30 cm plastic bag. In the laboratory samples were sieved through 2 mm and 1 mm mesh sieves to remove most large organic and soil matter. Small amounts of the sieved material were placed in a petri dish and examined under a stereomicroscope for the presence of dead mites. Ten to 25 mites from each sample were placed on filter paper on wet cotton wool in a plastic cup (10 cm diameter). Following absorption of moisture, each mite was dissected to expose the contained eggs and the number recorded. They were then stored at 17.5°C, L:D 15:9, a temperature optimal for post-diapause development of *H. destructor* eggs (Wallace 1970a). Cups were held in a metal tray filled with water to ensure eggs were continually exposed to moisture. After 14 days eggs were examined and recorded as developed (hatched or at deutovum stage), undeveloped (diapause) or dead. Dead eggs lost their contents and remained as shells only. In each sample 300-800 eggs were examined.

Temperature and rainfall data for the sampling period were obtained from the YAI meteorological station situated approximately mid-way between the two sampling sites.

*Effect of soil type and moisture on egg diapause termination and mortality*

Dead mites containing oversummering eggs were placed on sand, loam or clay under wet or dry conditions during November - February, 1989/90. Soil was contained in seedling boxes (40 x 30 x 12 cm, one per treatment) held outdoors but protected from rain by plastic

**Table 1.** Percentage development (upper two lines) and mortality (lower two lines) of oversummering eggs of *H. destructor* collected from Leeton Field Station (LFS) and Yanco Agricultural Institute (YAI), in (a) 1988/89, (b) 1989/90 and (c) overall means 1988/90.

| | 22 Nov | 15 Dec | 6 Jan | 20 Jan | 3 Feb | 14 Feb | 1 Mar |
|---|---|---|---|---|---|---|---|
| YAI | 0 | 50.8 | 58.0 | 73.7 | 65.0 | 75.9 | 90.7 |
| LFS | 0 | 40.0 | 17.5 | 30.0 | 42.4 | 46.9 | 69.6 |
| | | | | | | | |
| YAI | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LFS | 0 | 0 | 0 | 23 | 11.6 | 5.5 | 7.5 |

(a) 1988/89

| | 22 Nov | 6 Dec | 20 Dec | 3 Jan | 17 Jan | 31 Jan | 14 Feb |
|---|---|---|---|---|---|---|---|
| YAI | 8.0 | 16.7 | 49.6 | 77.5 | 86.4 | 95.7 | 83.1 |
| LFS | 2.2 | 5.2 | 4.0 | 68.7 | 63.7 | 94.7 | – |
| | | | | | | | |
| YAI | 0 | 0.8 | 1.9 | 0 | 4.6 | 2.9 | 0 |
| LFS | 0 | 0.9 | 12.4 | 11.3 | 3.4 | 3.4 | – |

(b) 1989/90

| | |
|---|---|
| YAI | 59.4[a] |
| LFS | 37.3 |
| | |
| YAI | 0.7[a] |
| LFS | 6.1 |

(c) Means 1988/90

[a] significant difference from LFS ($P<0.05$)

sheeting positioned 1 m above the boxes. Saturation of soil in wet treatments was maintained by placing boxes in water filled trays. In each box ten groups of 50 - 100 mites were placed on the soil surface. Mites were obtained from a local field population in October and contained 100% diapause eggs. They were left to die in the laboratory and placed in experimental conditions within a week of death. At fortnightly intervals one group of mites from each of the treatments was examined. Five to 25 mites from each treatment were placed on filter paper, dissected to expose eggs and assessed for development and mortality as described above. In each sample 200-800 eggs were examined. Data were analysed using ANOVA and LSD procedures ($P<0.05$)

**Results**

*Egg diapause termination and mortality in field populations*

Termination of egg diapause occurred in most of the population during December. Development occurred in the majority of eggs ($\bar{x}$ = 71.3 ± 4.6) from all January samples except those from LFS in 1989 (Table 1). Egg development was greater and mortality lower at YAI than LFS when analysed over the two seasons ($P<0.05$). Egg development at LFS in 1988/89 did not exceed 60% until late February and mortalities ($\bar{x}$ = 13.4 ± 3.6) occurred in January/February.

**Table 2.** Yanco Agricultural Institute Rainfall data (mm) for November-February.

| | 1988/89 | | | 1989/90 | | |
|---|---|---|---|---|---|---|
| Month | 30 yr mean | Actual | % of 30 yr | 30 yr mean | Actual | % of 30 yr |
| November | 32.1 | 53.4 | 166 | 31.7 | 17.3 | 55 |
| December | 30.7 | 70.6 | 230 | 30.3 | 9.7 | 32 |
| January | 31.7 | 11.2 | 35 | 31.7 | 31.7 | 100 |
| February | 27.0 | 1.2 | 4 | 28.7 | 109.2 | 380 |

Rainfall was equal to or below the long term average in all months except November and December, 1988 and February, 1990 Table 2). Temperatures did not deviate greatly from long term means.

*Effect of soil type and moisture on egg diapause termination and mortality*

Soil type and the presence or absence of moisture had no significant effect on timing or extent of diapause termination as indicated by percentage of eggs developed over the sampling period (Table 3) ($P>0.05$). Mortality was lower on dry soils ($\bar{x}$ = 3.3%) than wet soils ($\bar{x}$ = 16.6%) with mortality on wet sand significantly greater than in any other treatment (Table 3) ($P<0.05$). On wet soils greatest mortality occurred in late December and early January, whilst on dry soils mortality tended to increase as summer progressed.

**Discussion**

Mortality in oversummering egg populations and diapause termination must be considered in any analysis of the seasonal population substantially influence population size and thus pest status. This study dynamics of *H. destructor*. Both factors have the potential to indicate that site, soil type and moisture can have a significant effect

**Table 3.** Percentage development (a) and mortality (b) of oversummering eggs of *H. destructor* collected from dry or wet sand, loam and clay during November-February 1989/90 and (c) means for wet and dry soils.

| | 22 Nov | 6 Dec | 20 Dec | 3 Jan | 17 Jan | 31 Jan | 14 Feb | MEAN |
|---|---|---|---|---|---|---|---|---|
| Wet loam | 2.1 | 23.6 | 20.6 | 69.6 | 60.2 | 77.3 | 34.3 | 41.1[a] |
| Wet clay | 7.9 | 30.4 | 8.1 | 74.2 | 77.0 | 67.1 | 80.8 | 49.4[a] |
| Wet sand | 11.3 | 36.4 | 26.4 | 40.2 | 54.5 | 62.0 | 25.3 | 36.6[a] |
| Dry loam | 11.7 | 18.6 | 32.1 | 53.9 | 60.5 | 61.8 | 42.7 | 40.2[a] |
| Dry clay | 7.5 | 12.9 | 35.1 | 53.9 | 39.1 | 47.6 | 41.6 | 34.0[a] |
| Dry sand | 6.7 | 10.1 | 31.3 | 34.7 | 42.5 | 53.6 | 64.9 | 34.8[a] |

(a) Development

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Wet loam | 0 | 3.5 | 16.0 | 15.4 | 14.4 | 13.4 | 10.7 | 10.5[b] |
| Wet clay | 0 | 2.7 | 34.2 | 12.5 | 5.4 | 12.4 | 6.5 | 10.5[b] |
| Wet sand | 0 | 3.3 | 70.8 | 46.4 | 10.0 | 15.9 | 54.6 | 28.7[c] |
| Dry loam | 0 | 3.5 | 1.9 | 2.1 | 1.9 | 2.8 | 2.5 | 2.1[d] |
| Dry clay | 0 | 1.2 | 0 | 5.4 | 2.7 | 1.5 | 4.9 | 2.2[d] |
| Dry sand | 0 | 4.5 | 4.9 | 7.1 | 7.2 | 10.8 | 4.2 | 5.5[d] |

(b) Mortality

| Soil | Development | Mortality |
|---|---|---|
| Wet | 42.3[a] | 16.6[b] |
| Dry | 36.3[a] | 3.3[d] |

(c) Overall means

Values followed by different superscript letter are significantly different ($P < 0.05$)

on both diapause termination and mortality.

The well drained dryland site on sandy loam (YAI) was more favourable to the survival and post-diapause development of *H. destructor* than the poorly drained, clay site (LFS). This is in agreement with the observation that *H. destructor* prefers light, sandy soils (Tucker 1925). Differences in effectiveness of diapause termination and mortality were most marked in 1988/89. This season was characterised by above average rainfall in November and December. This would have resulted in prolonged exposure of moist eggs on poorly drained soils to high summer temperatures with consequent mortality (Wallace 1970a). The reduction in development capability at the poorly drained site may be attributable to the flush of summer vegetation following rainfall, reducing the exposure of eggs to high temperatures. The exposure of dry diapausing eggs to hot temperatures is a necessary precursor to diapause termination (Wallace 1970a). At the well drained site eggs were probably not exposed to prolonged moisture and minimal growth of vegetation occurred ensuring maximum exposure of the eggs to high temperatures. In 1989, November and December were relatively dry and although mortality was higher and competency to develop lower at LFS than at YAI, it was not as marked as in the previous year.

Different soil types and the presence or absence of moisture did not have a great effect on diapause termination in the controlled experiments. This may be explained by the wet treatments not having vegetation to shield eggs from high temperatures as occurred in the field following summer rainfall. Continuously wet soils caused higher egg mortality than dry soils. Wet sand caused highest mortality but it is important to note that this result has little significance to the field situation where sandy soil because of its good drainage, would be unlikely to remain wet for any length of time during summer. Mortality in wet treatments was usually greatest during late December/early January declining to some extent in later samples. Egg death was characterised by swelling, rupturing and resultant loss of contents leaving only the shell. Consequently, samples taken later in January and February contained eggs which had not succumbed to exposure to heat and moisture for more than 3 months. The population had, in effect, been selected for those individuals less susceptible to the combination of heat and moisture. It is also likely that mortality in wet treatments would have been underestimated due to no account being taken of deaths prior to sampling.

These results indicate that high rainfall in early to mid summer has a significant deleterious effect on survival of post-diapause oversummering eggs of *H. destructor*. The lethality of hot conditions (30-50°C) to moist oversummering eggs of *H. destructor* (Wallace 1970a), indicates that they are probably vulnerable to rainfall-induced mortality for most of the summer. This effect would be most marked on soils which retain moisture, but of minor importance on well drained soils. The adverse effect of moisture on oversummering eggs could be a major factor in determining local abundance and distribution of *H. destructor* in southern New South Wales. The possibilities of using summer flooding of pastures in irrigated areas as part of a management strategy for *H. destructor* should be examined.

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